Computational Models of the Eye and their Applications in Long Duration Space Flight

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Astronauts are exposed to cephalad fluid shift, increased carbon dioxide levels and other environmental factors during space flight. As a result of these conditions, it is believed that they are at risk of developing increased intracranial pressure (ICP) and intraocular pressure (IOP), which in turn may cause papilledema and other disorders of the eye that can lead to temporary or permanent changes in vision. However, the mechanisms behind this risk are not fully understood. Ground analog and flight studies pose challenges because there are limited non-invasive methods that can be used to study the eye and intracranial space. Therefore it is proposed that computational models can be applied to help address this gap by providing a low cost method for studying the effects of IOP, ICP and various properties of the eye on these diseases. The information presented by the authors provides a summary of several models found in literature that could potentially be augmented and applied to inform research. Specifically, finite element models of the optic nerve head, sclera and other structures of the eye can be readily adapted as potential building blocks. These models may also be integrated with a brain/cerebrospinal fluid (CSF) model which will take into account the interaction between the CSF fluid and its pressure on the optic nerve. This integration can enable the study of the effects of microgravity on the interaction between the vasculature system and CSF system and can determine the effects of these changes on the optic nerve, and in turn the eye. Ultimately, it can help pinpoint the influences of long-term exposure to microgravity on vision and inform the future research into countermeasure development. In addition to spaceflight, these models can provide deeper understanding of the mechanisms of glaucoma, papilledema and other eye disorders observed in terrestrial conditions.